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Open File Report 90-5

**ALBERT MINES OIL SHALE DEPOSIT
DRILL CORE RESAMPLING AND CALCIUM
ANALYSIS**

by

THREE-D GEOCONSULTANTS LIMITED



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Mineral
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Hon. Morris Green, Minister

June, 1990

ALBERT MINES OIL SHALE DEPOSIT
DRILL CORE RESAMPLING AND CALCIUM
ANALYSIS

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**ALBERT MINES OIL SHALE DEPOSIT
DRILL CORE RESAMPLING AND CALCIUM
ANALYSIS
REPORT 8814-1**

Prepared for: Canadian Occidental
Petroleum Ltd.
Alternate Fuels
Division
Calgary, Alberta

Prepared by: Three-D
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August 31, 1988



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Canadian Occidental Petroleum Ltd.
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Calgary, Alberta
T2P 3Z1

Attention: Dr. E. Yildirim, General Manager
New Technology, Coal and Minerals

Dear Dr. Yildirim:

Re: Albert Mines Oil Shale Deposit - Core Analysis
MISP Project 8801-21H15
Report 8814-1

I am pleased to submit four copies of the final report for this project.

This last opportunity to avail ourselves of the 1976 drill core in its unabbreviated form was one not to be missed. The availability of the 686 calcium analyses for the Albert Mines oil shale deposit reported herein will aid future endeavours in delineating the inorganic geochemistry of the deposit. You will note that we have retained a split from each sample which can be utilized in the future for other analyses should that be found necessary.

I believe that Mr. Robert Harris, Coordinator of the Mineral Investment Stimulation Program for the New Brunswick Department of Natural Resources and Energy expects to receive two copies of this report. I trust you will be forwarding those copies directly.

Yours truly,

Dwight Ball

SUMMARY

All analytical and associated geological and developmental work at the Albert Mines oil shale deposit has until recently concentrated on its hydrocarbon content. Recent interest in coal-oil shale circulating fluidized bed cocombustion has necessitated additional evaluation of the deposit's inorganic geochemistry. In particular the distribution of calcium in the deposit has come under increasing scrutiny. Until now, however, a deficient inorganic geochemical data base for the deposit has made that evaluation difficult.

Four of the core holes drilled by Canadian Occidental Petroleum Ltd. in 1976 and previously only analyzed for shale oil yield have been resampled. A total of 686 drill core samples have been analyzed for the calcium content of the carbonate minerals present. The resampling program has duplicated the 1976 sampling in order to permit direct comparison of calcium content and shale oil yields on a sample by sample basis.

The four lithologic zones which make up the Albert Mines oil shale deposit are, in descending stratigraphic order: 1) the upper shale zone, 2) the Albert Mines zone, 3) the clay marlstone zone and 4) the dolomite marlstone zone. The average available calcium content of these zones are: 1) 7.93, 2) 7.61, 3) 4.01, and 4) 4.57 weight percent. The average shale oil yields of these zones are: 1) 36.10, 2) 79.21, 3) 21.84 and 4) 51.46 litres/tonne.

The program of sampling and analyses reported here has been funded jointly by Canadian Occidental Petroleum Ltd. and the Mineral Investment Stimulation Program of the New Brunswick Department of Natural Resources and Energy.

RÉSUMÉ

Jusqu'à récemment, tous les travaux d'analyse et les activités géologiques et de mise en valeur connexes exécutés au gisement de schistes bitumineux d'Albert Mines ont été concentrés sur leur teneur en hydrocarbures. L'intérêt récemment manifesté pour la cocombustion des schistes bitumineux et houillers sur lit fluidisé à turbulence a nécessité une nouvelle évaluation de la géochimie inorganique du gisement. Tout particulièrement, la répartition du calcium dans le dépôt a fait l'objet d'études plus approfondies. Toutefois, jusqu'à présent, une base de données insuffisantes sur la géochimie inorganique du gisement a compliqué la tâche des évaluateurs.

Quatre des trous creusés par la Canadian Occidental Petroleum Ltd. en 1976 et dont les carottes n'ont fait l'objet d'analyses concernant la teneur en pétrole des schistes ont été soumis à de nouveaux travaux d'échantillonnage. En tout, les chercheurs ont effectué l'analyse de 686 échantillons de carottes afin de déterminer la teneur en calcium des minéraux carbonatés. Les nouveaux travaux d'échantillonnage reprennent le programme de 1976 afin de permettre la comparaison directe des échantillons quant à leur teneur en calcium et en pétrole.

Voici, en ordre stratigraphique descendant, les quatre zones pétrographiques constituant le gisement de schistes bitumineux d'Albert Mines : 1) zone schisteuse supérieure, 2) zone d'Albert Mines, 3) zone de marne indurée argileuse et, 4) zone de marne indurée dolomitique. Voici également les chiffres sur la teneur moyenne en calcium de ces zones : 1) 7,93 pour cent du poids, 2) 7,61 pour cent, 3) 4,01 pour cent et, 4) 4,57 pour cent. Quant à la teneur moyenne en pétrole des schistes bitumineux, voici les chiffres recueillis dans chaque zone : 1) 36,10 litres/tonne, 2) 79,21 l/t, 3) 21,84 l/t et, 4) 51,46 l/t.

Le programme d'incitation à l'investissement dans le secteur minier dont il est question dans le présent document a été financé conjointement par la Canadian Occidental Petroleum Ltd. et le ministère des Ressources naturelles et de l'Énergie du Nouveau-Brunswick dans le cadre du Programme de stimulation de l'investissement dans le secteur minéral (PSISN).

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1.0 INTRODUCTION

The Albert Mines oil shale deposit has, since its discovery in the middle of the last century, been the subject of attention due to its hydrocarbon content. As a result, until 1982 all analytical and associated geological and developmental work at the deposit concentrated on its hydrocarbon content. More recently and specifically since the inception of the concept of coal-oil shale circulating fluidized bed cocombustion, an interest in and indeed a necessity to understand the inorganic geochemistry of the deposit has developed. To date, however, the inorganic geochemical data base for the deposit has been far from adequate. Determination of the distribution of the inorganic mineralogy of the deposit has been based primarily upon approximately 200 semi-quantitative X-ray diffraction analyses completed on "grab" samples picked at irregular intervals from the drill core; each sample representing only 2 to 3 centimeters of stratigraphic section. Although adequate to enable the prediction of general mineralogical trends within the deposit, this data base did not permit accurate quantification of the distribution of elements. The actual content of calcium in any particular lithologic unit within the deposit was not known and therefore

open to speculation. Calcium is the key element in terms of sulphur sorbency in cocombustion therefore an understanding of its distribution in the oil shales has become as important as understanding that of the hydrocarbons.

In late 1987 the New Brunswick Department of Natural Resources and Energy announced their intention to abbreviate some of the drill core held in the Fredericton depository. A large portion of the Albert Mines drill core was stored in badly deteriorated boxes and portions of the core itself had severely deteriorated due to exposure to weather. The state of the core was the result of its storage in inadequate facilities prior to its removal to the Fredericton depository in 1982. The Albert Mines core was therefore amongst that slated by the Department for substantial reduction through abbreviation. It was decided that at the time the boxes of core were to be unracked for abbreviation and reboxing, the core should be resampled for calcium analyses. The abbreviation process would limit the volume of core to be retained thus limiting the effectiveness of any sampling to be undertaken at a later date. The winter of 1988 was therefore the last opportunity for unrestricted

sampling of the Canadian Occidental Albert Mines core, drilled, split and assayed for shale oil yield in 1976. As part of the 1988 program, a portion of the pulverized samples have been retained in storage should subsequent reanalyses for other elements be deemed worthwhile.

2.0 DRILL CORE SAMPLING

The core affected by the abbreviation included four holes cored at Albert Mines by Canadian Occidental Petroleum Ltd. in 1976. The hole numbers are 2, 4, 5, and 6. These cores, their lithology logs and Fischer Assay results have been key to the development of the geological model which exists for the deposit and is presented in Report 8434-2, submitted on March 29, 1985. The sections of the cores which cut oil shales had been split and Fischer Assayed immediately after their recovery in 1976. As a result of these activities approximately 970 Fischer Assays representing 4,850 feet of core (1 sample = 5' of core) are on file for these four drill holes.

The samples originally prepared for Fischer Assay each represented 5 feet of drill core. Each sample was composed of approximately one-half of the recovered drill core, split longitudinally, crushed, pulverized, split to the appropriate sample size and Fischer Assayed for shale oil and water yield. In order to generate calcium analyses which are directly correlatable to the Fischer Assays the original samples and sampling techniques were duplicated in terms of footage and methodology. In order that a portion of

the core, where available remain in storage, only 1/3 of the remaining half of the core was taken for calcium analysis. Sampling proceeded utilizing two methods, the use of either method for any particular sample depended upon the state of preservation of the core. A substantial portion of core remained intact and was sampled by splitting with a diamond rock saw. Those sections of the core which had deteriorated to rubble were hand picked using an appropriately sized scoop. Care was taken to sample approximately 1/3 of the rubble chips and to maintain footage control. The state of preservation of the core dictated that many of the 5 foot sample intervals were unidentifiable. Such samples were amalgamated over 10, 15, or 20 foot intervals thus reducing the total number of samples analyzed and plotted herein. As a result, although the original Fischer Assays were completed on 970 samples representing 4,850 feet of core, calcium analyses were completed on only 686 samples. These samples represent the same footage intervals although several samples represent core lengths greater than 5' and since some portions of the core were missing, the calcium analyses results have gaps in their continuity.

3.0 SAMPLE ANALYSES

3.1 Methods

The drill core samples, each weighing 1 to 1.5 kilograms, were transported to the New Brunswick Research and Productivity Council for preparation and analysis. The samples were air-dried, crushed, split to obtain a representative sample then pulverized to-100 mesh size. Weighed pulverized samples were ashed at 550°C, digested in 1:1 HCL + H₂O and diluted to the appropriate volume. The solutions were then analyzed for calcium using a Varian AA 975 (atomic absorption spectrophotometer) with the addition of potassium as an ionization suppressant. As quality control, certified standards were analyzed with each batch of samples. The inorganic mineral digestion technique utilized yields analyses results which quote available calcium content, that is, the calcium associated with the carbonate minerals in the oil shales.

This was the last opportunity for unrestricted sampling of the Canadian Occidental Albert Mines core, drilled in 1976. A portion of the pulverized samples have, therefore, been retained in storage should subsequent reanalyses for other elements be deemed worthwhile.

3.2 Results

The calcium analyses results are listed in the Appendices. The results were subdivided according to the lithologic units previously identified in the Albert Mines Deposit and are synthesized on Table 1. The average calcium content of each lithologic unit in each drill hole and for all four drill holes sampled are listed. In addition, the average shale oil yield for each lithologic unit in each drill hole is listed as well as for each unit for the entire deposit. The overall average shale oil yields for each lithologic unit result from a total of 43 holes drilled in the deposit by various interests since the early 1940's. Synthesis of the shale oil yields are presented and discussed in detail in Report 8434-2.

The upper shale and Albert Mines zones of the Albert Mines oil shale deposit are composed of oil shales, which on average, contain the largest percentages of available calcium (associated with carbonates) of the four lithologic units which makeup the deposit. The analyses undertaken indicate an average calcium content for the upper shale zone of 7.93% with a range of 2.95 to 16.40%. The values for the Albert Mines zone

Drill Hole #	Lithologic Zone	Number of Samples (Ca analyses only)	% Calcium Range			Shale Oil Yield Ltrs/tonne
			Max	Min	Ave	
2	upper shale	16	11.85	4.43	8.66	42.50
2	Albert Mines	57	18.78	4.03	7.81	108.80
2	clay marlstone	2	4.83	3.39	4.11	33.70
4	Albert Mines	51	12.20	2.46	7.09	80.50
4	clay marlstone	8	3.98	1.11	2.21	10.30
5	upper shale	62	16.40	2.95	7.74	43.40
5	Albert Mines	37	14.00	4.43	8.00	110.30
5	clay marlstone	42	12.20	1.06	4.42	44.80
5	dolomite marlstone	237	7.82	1.78	4.50	52.10
6	clay marlstone	30	8.24	1.36	3.91	64.70
6	dolomite marlstone	142	7.92	2.60	4.68	63.00
overall average	upper shale	78	16.40	2.95	7.93	36.10*
"	Albert Mines	145	18.78	2.46	7.61	79.21
"	clay marlstone	82	12.20	1.11	4.01	21.84
"	dolomite marlstone	381	7.92	1.78	4.57	51.46*

* includes shale oil yields from 43 drill holes 3803 individual samples
(Table 2, Report 8434-2, March 29, 1985)

Table 1 Summary of the calcium content of four holes drilled in the Albert Mines oil shale deposit compared with the deposit's shale oil content.

average 7.61%, ranging between 2.46 and 18.78%. The calcium content of these two zones appear to be essentially the same. The average shale oil yield values for the two zones, however, as previously reported (Report 8434-2, March 29, 1985), differ markedly. The upper shale zone averages 36.10 litres/tonne where as the Albert Mines zone, the premier shale oil zone in the deposit averages 79.21 litres/tonne.

The available calcium content of the clay marlstone zone averages 4.01% and ranges between 1.11 and 12.20%. The available calcium content of the dolomite marlstone zone averages 4.57% and ranges between 1.78 and 7.92%. The shale oil yields for these two zones average 21.84 and 51.46 litres per tonne, respectively.

4.0 INTERPRETATION

The shale oil yields in the upper shale and Albert Mines zones vary markedly from sample to sample. This is a reflection of the well developed bedding in these zones and of the compositional variation between those beds. The available calcium content for these two zones varies similarly although not necessarily directly with the shale oil yield. In fact in many instances the calcium content and shale oil yield, at the bed scale, vary indirectly, a phenomena noted during the completion of previous studies. Irrespective of calcium variability, the minimum calcium content of either of these two zones is approximately double that of the minimum of either the clay or dolomite marlstone zones.

The shale oil yields in the dolomite marlstone zone vary cyclically at a scale between 25 and 60 metres; a phenomena noted during the completion of previous studies. The available calcium content of the zone varies similarly but is commonly out-of-phase with the shale oil yield, as previously suspected. The cyclic nature of the calcium content is not, however, as evident as that of the shale oil yield and does in some sections of the drill core very in-phase with the shale oil yield. Relative variabilities of the shale oil yields and calcium contents between zones and between samples within the zones are most readily visualized on the log of hole #5 which cut a nearly complete stratigraphic section through the deposit.

The calcium content and shale oil yield of the clay marlstone zone are the lowest of the four lithologic

units which makeup the deposit. The zone's previously noted elevated clay content combined with its now documented minimal calcium content suggests that the zone be treated as waste.

5.0 CONCLUSIONS

The four lithologic zones which makeup the Albert Mines oil shale deposit are, in descending stratigraphic order: 1) the upper shale zone, 2) the Albert Mines zone, 3) the clay marlstone zone and 4) the dolomite marlstone zone. The average available calcium content of these zones are: 1) 7.93, 2) 7.61, 3) 4.01, and 4) 4.57 weight percent. These figures can be composed with the average shale oil yields of the zones which are: 1) 36.10, 2) 79.21, 3) 21.84, and 4) 51.46 litres/tonne.

The Albert Mines zone, in total, has the optimum available calcium content and shale oil yield. The zone does, however, have elevated clay mineral content which could present handling and processing difficulties particularly when the material becomes weathered through exposure.

The clay marlstone zone, with low calcium content and shale oil yield and elevated clay mineral content is effectively a zone of waste.

The inverse relationship between the average calcium content and average shale oil yield of the upper shale and dolomite marlstone zones suggest that blending of the two oil shale types could offer potential in a development plan.

The scale of the variation of the calcium content and shale oil yield of the oil shales must be kept in perspective.

The sample interval presented in this report is 5 feet and it is obvious that considerable variation exists between the samples analyzed even within a single lithologic zone. In the field, during any sampling program, the difficulty is one of access to a thickness of the stratigraphic section sufficient to permit representative sampling.

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A P P E N D I X 1

Calcium analyses:

Albert Mines Diamond Drill Hole #76-4

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Upper Shale	68-73	6.56	Albert Mines	505-510	7.35
Upper Shale	135-140	5.49	Albert Mines	510-515	7.09
Upper Shale	140-145	8.04	Albert Mines	515-520	6.28
Upper Shale	150-155	10.80	Albert Mines	520-525	18.78
Upper Shale	155-160	12.13	Albert Mines	525-530	6.84
Upper Shale	160-165	7.97	Albert Mines	530-535	5.67
Upper Shale	165-170	10.21	Albert Mines	535-540	7.07
Upper Shale	170-175	11.85	Albert Mines	540-545	8.17
Upper Shale	185-190	11.56	Albert Mines	545-550	5.98
Upper Shale	215-220	7.78	Albert Mines	550-555	6.60
Upper Shale	220-225	10.99	Albert Mines	555-560	5.78
Upper Shale	225-230	8.09	Albert Mines	560-565	5.90
Upper Shale	230-235	8.07	Albert Mines	565-570	6.54
Upper Shale	235-240	7.28	Albert Mines	570-575	6.92
Upper Shale	240-245	4.43	Albert Mines	575-580	9.88
Upper Shale	270-275	9.30	Albert Mines	580-585	6.89
Albert Mines	300-305	10.50	Albert Mines	585-590	6.62
Albert Mines	305-310	8.63	Albert Mines	590-595	10.54
Albert Mines	310-315	16.12	Albert Mines	595-600	9.84
Albert Mines	315-320	7.10	Albert Mines	600-605	10.00
Albert Mines	320-325	5.51	Albert Mines	605-610	8.57
Albert Mines	325-330	4.03	Albert Mines	610-614	5.00
Albert Mines	350-355	7.28	Clay Harst.	787-790	4.83
Albert Mines	355-360	5.60	Clay Harst.	790-795	3.39
Albert Mines	360-365	8.46			
Albert Mines	365-370	9.90			
Albert Mines	370-375	3.76			
Albert Mines	375-380	3.40			
Albert Mines	380-385	4.68			
Albert Mines	385-390	5.04			
Albert Mines	390-395	9.35			
Albert Mines	395-400	7.04			
Albert Mines	400-405	8.99			
Albert Mines	405-410	10.22			
Albert Mines	410-415	11.56			
Albert Mines	415-420	6.89			
Albert Mines	420-425	4.66			
Albert Mines	425-430	4.08			
Albert Mines	430-435	6.74			
Albert Mines	435-440	9.46			
Albert Mines	440-445	6.48			
Albert Mines	445-450	7.33			
Albert Mines	450-455	10.08			
Albert Mines	455-460	12.81			
Albert Mines	460-465	12.59			
Albert Mines	465-470	8.85			
Albert Mines	481-485	6.56			
Albert Mines	485-490	9.26			
Albert Mines	490-495	7.24			
Albert Mines	495-500	5.94			
Albert Mines	500-505	7.48			

A P P E N D I X 2

Calcium Analysis:

Albert Mines Diamond Drill Hole #76-4

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Albert Mines	1403-1408	8.15	Albert Mines	1623-1628	10.33
Albert Mines	1408-1413	2.92	Albert Mines	1628-1633	8.76
Albert Mines	1413-1418	2.46	Albert Mines	1633-1638	6.26
Albert Mines	1418-1423	8.07	Albert Mines	1638-1643	8.80
Albert Mines	1423-1428	8.75	Albert Mines	1643-1648	4.19
Albert Mines	1428-1433	6.02	Albert Mines	1648-1653	4.95
Albert Mines	1433-1438	5.93	Albert Mines	1653-1657.5	5.11
			Clay Marlst.	1657-1668	2.48
Albert Mines	1443-1445.5	0.24	Clay Marlst.	1668-1673	2.30
Albert Mines	1445-1450	5.77	Clay Marlst.	1673-1678	1.11
Albert Mines	1450.5-1453	6.40	Clay Marlst.	1678-1688	2.48
Albert Mines	1453-1458	5.89	Clay Marlst.	1688-1693	1.64
Albert Mines	1455-1458	5.53	Clay Marlst.	1693-1698	3.98
Albert Mines	1458-1463	10.58	Clay Marlst.	1698-1703	2.41
Albert Mines	1463-1468	4.61	Clay Marlst.	1703-1708	1.30
Albert Mines	1468-1473	5.77			
Albert Mines	1473-1478	8.59			
Albert Mines	1478-1483	12.20			
Albert Mines	1483-1488	9.04			
Albert Mines	1488-1493	3.41			
Albert Mines	1493-1498	4.18			
Albert Mines	1498-1503	5.81			
Albert Mines	1503-1508	6.51			
Albert Mines	1508-1513	5.81			
Albert Mines	1513-1518	6.49			
Albert Mines	1518-1523	7.90			
Albert Mines	1528-1533	8.16			
Albert Mines	1533-1538	8.85			
Albert Mines	1538-1543	8.10			
Albert Mines	1543-1548	10.94			
Albert Mines	1548-1553	5.39			
Albert Mines	1553-1558	8.19			
Albert Mines	1558-1563	7.53			
Albert Mines	1563-1568	8.72			
Albert Mines	1568-1573	7.54			
Albert Mines	1573-1578	7.00			
Albert Mines	1578-1583	4.75			
Albert Mines	1583-1588	8.48			
Albert Mines	1588-1591.5	8.30			
Albert Mines	1598-1603	8.34			
Albert Mines	1603-1608	4.55			
Albert Mines	1608-1613	4.60			
Albert Mines	1613-1618	7.82			
Albert Mines	1618-1623	8.58			

A P P E N D I X 3

Calcium Analysis:

Albert Mines Diamond Drill Hole #76-5

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Upper Shale	45-50	10.61	Upper Shale	405-410	4.47
Upper Shale	50-55	7.64	Upper Shale	410-415	9.98
Upper Shale	55-60	10.26	Upper Shale	493-495	5.89
Upper Shale	60-65	9.17	Upper Shale	500-505	13.00
Upper Shale	65-70	11.60	Upper Shale	505-510	8.75
Upper Shale	70-72.9	7.14	Upper Shale	510-515	10.00
Upper Shale	85-90	7.77	Upper Shale	515-519	8.45
Upper Shale	90-95	6.84	Upper Shale	540-545	16.40
Upper Shale	95-100	9.14	Upper Shale	589-594	7.06
Upper Shale	100-105	9.13	Upper Shale	594-598	5.22
Upper Shale	105-110	6.83	Upper Shale	600-615	5.05
Upper Shale	110-115	6.91	Albert Mines	625-630	5.22
Upper Shale	120-125	6.78	Albert Mines	630-635	6.02
Upper Shale	125-130	8.46	Albert Mines	635-640	4.79
Upper Shale	130-135	9.59	Albert Mines	640-645	8.72
Upper Shale	135-140	8.44	Albert Mines	645-650	7.30
Upper Shale	140-145	8.22	Albert Mines	650-655	8.36
Upper Shale	145-150	9.16	Albert Mines	655-659	8.30
Upper Shale	150-155	6.52	Albert Mines	667-670	11.80
Upper Shale	155-160	7.91	Albert Mines	670-675	12.00
Upper Shale	160-165	4.99	Albert Mines	675-680	5.99
Upper Shale	1663-181	7.14	Albert Mines	680-685	4.43
Upper Shale	181-185	7.94	Albert Mines	685-687	4.98
Upper Shale	185-190	9.14	Albert Mines	735-740	7.52
Upper Shale	190-195	7.50	Albert Mines	740-745	9.06
Upper Shale	195-200	5.06	Albert Mines	745-750	9.88
Upper Shale	200-205	4.26	Albert Mines	750-754	14.00
Upper Shale	205-210	4.70	Albert Mines	771-775	6.56
Upper Shale	210-215	5.68	Albert Mines	775-780	8.32
Upper Shale	215-220	11.30	Albert Mines	780-785	9.47
Upper Shale	220-225	10.10	Albert Mines	785-800	11.60
Upper Shale	225-230	11.60	Albert Mines	800-805	6.40
Upper Shale	230-235	10.80	Albert Mines	805-810	5.80
Upper Shale	235-240	12.40	Albert Mines	810-815	6.88
Upper Shale	240-245	4.05	Albert Mines	815-820	12.20
Upper Shale	252-256	6.34	Albert Mines	820-823	6.60
Upper Shale	261.25-265	8.33	Albert Mines	823-838	7.08
Upper Shale	265-270	5.30	Albert Mines	838-840	8.93
Upper Shale	270-275	3.53	Albert Mines	840-843	6.44
Upper Shale	275-280	11.27	Albert Mines	843-849	6.69
Upper Shale	280-285	5.54	Albert Mines	850-855	5.95
Upper Shale	285-290	5.17	Albert Mines	855-860	6.20
Upper Shale	321-331	6.75	Albert Mines	860-865	9.21
Upper Shale	336-340	8.14	Albert Mines	880-883	9.97
Upper Shale	340-345	5.49	Albert Mines	883-888	9.78
Upper Shale	365-370	5.09	Albert Mines	888-890	6.77
Upper Shale	370-375	6.23	Albert Mines	890-905	9.52
Upper Shale	385-390	2.95	Albert Mines	905-909	7.18
Upper Shale	390-395	3.78	Clay Marlst.	909-920	9.03
Upper Shale	395-400	9.36	Clay Marlst.	920-925	10.56
Upper Shale	400-405	7.66	Clay Marlst.	925-930	8.76

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Clay Marlst.	930-935	9.13	Dolomite Marlst.	1350-1355	5.97
Clay Marlst.	948-960	8.89	Dolomite Marlst.	1355-1360	5.80
Clay Marlst.	996-1000	1.56	Dolomite Marlst.	1360-1365	4.55
Clay Marlst.	1000-1005	4.78	Dolomite Marlst.	1365-1370	5.50
Clay Marlst.	1005-1010	1.10	Dolomite Marlst.	1370-1375	6.57
Clay Marlst.	1110-1115	1.66	Dolomite Marlst.	1375-1380	6.22
Clay Marlst.	1115-1120	2.39	Dolomite Marlst.	1380-1385	4.32
Clay Marlst.	1120-1125	3.20	Dolomite Marlst.	1385-1390	3.24
Clay Marlst.	1125-1130	2.45	Dolomite Marlst.	1390-1395	3.01
Clay Marlst.	1130-1135	3.55	Dolomite Marlst.	1395-1400	4.18
Clay Marlst.	1135-1140	2.10	Dolomite Marlst.	1400-1405	2.97
Clay Marlst.	1140-1145	1.72	Dolomite Marlst.	1405-1410	5.30
Clay Marlst.	1145-1150	1.31	Dolomite Marlst.	1410-1415	4.49
Clay Marlst.	1150-1155	1.71	Dolomite Marlst.	1415-1420	3.51
Clay Marlst.	1155-1160	1.06	Dolomite Marlst.	1420-1425	3.30
Clay Marlst.	1160-1165	1.98	Dolomite Marlst.	1425-1430	3.72
Clay Marlst.	1165-1170	6.90	Dolomite Marlst.	1430-1435	4.79
Clay Marlst.	1170-1175	1.56	Dolomite Marlst.	1435-1440	3.12
Clay Marlst.	1175-1180	6.90	Dolomite Marlst.	1440-1445	4.12
Clay Marlst.	1180-1185	3.68	Dolomite Marlst.	1445-1450	4.14
Clay Marlst.	1185-1190	6.74	Dolomite Marlst.	1450-1455	4.51
Clay Marlst.	1190-1195	6.08	Dolomite Marlst.	1455-1460	4.68
Clay Marlst.	1195-1200	2.78	Dolomite Marlst.	1460-1465	3.92
Clay Marlst.	1200-1205	4.85	Dolomite Marlst.	1465-1470	5.76
Clay Marlst.	1205-1210	2.88	Dolomite Marlst.	1470-1475	7.13
Clay Marlst.	1210-1215	2.81	Dolomite Marlst.	1475-1480	7.58
Clay Marlst.	1215-1220	2.09	Dolomite Marlst.	1500-1505	7.82
Clay Marlst.	1220-1225	3.83	Dolomite Marlst.	1505-1510	7.42
Clay Marlst.	1225-1230	2.80	Dolomite Marlst.	1510-1515	3.83
Clay Marlst.	1230-1235	3.38	Dolomite Marlst.	1515-1520	2.80
Clay Marlst.	1235-1240	4.87	Dolomite Marlst.	1520-1525	3.92
Clay Marlst.	1240-1245	6.65	Dolomite Marlst.	1525-1530	3.52
Clay Marlst.	1245-1248	12.20	Dolomite Marlst.	1530-1535	4.77
Clay Marlst.	1255-1260	4.10	Dolomite Marlst.	1535-1540	3.82
Clay Marlst.	1260-1265	2.20	Dolomite Marlst.	1540-1545	2.27
Clay Marlst.	1265-1270	7.32	Dolomite Marlst.	1545-1550	2.78
Clay Marlst.	1270-1275	3.09	Dolomite Marlst.	1550-1555	4.29
Clay Marlst.	1275-1280	4.28	Dolomite Marlst.	1555-1560	5.00
Clay Marlst.	1280-1285	6.64	Dolomite Marlst.	1560-1565	3.85
Dolomite Marlst.	1291-1295	2.78	Dolomite Marlst.	1565-1570	5.59
Dolomite Marlst.	1295-1300	6.08	Dolomite Marlst.	1570-1575	5.22
Dolomite Marlst.	1300-1305	6.13	Dolomite Marlst.	1575-1580	5.44
Dolomite Marlst.	1305-1310	5.58	Dolomite Marlst.	1580-1585	4.61
Dolomite Marlst.	1310-1315	7.48	Dolomite Marlst.	1585-1590	4.19
Dolomite Marlst.	1315-1320	9.22	Dolomite Marlst.	1590-1595	4.85
Dolomite Marlst.	1320-1325	6.72	Dolomite Marlst.	1595-1600	4.16
Dolomite Marlst.	1325-1330	5.90	Dolomite Marlst.	1600-1605	4.40
Dolomite Marlst.	1330-1335	7.16	Dolomite Marlst.	1605-1610	3.94
Dolomite Marlst.	1335-1340	5.60	Dolomite Marlst.	1610-1615	4.59
Dolomite Marlst.	1340-1345	5.24	Dolomite Marlst.	1615-1620	5.08
Dolomite Marlst.	1345-1350	5.50	Dolomite Marlst.	1620-1625	3.84

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Dolomite Marlst.	1625-1630	4.15	Dolomite Marlst.	1885-1890	3.24
Dolomite Marlst.	1630-1635	4.33	Dolomite Marlst.	1890-1895	4.43
Dolomite Marlst.	1635-1640	3.58	Dolomite Marlst.	1895-1900	3.64
Dolomite Marlst.	1640-1645	3.77	Dolomite Marlst.	1900-1905	4.00
Dolomite Marlst.	1645-1650	4.25	Dolomite Marlst.	1905-1910	4.76
Dolomite Marlst.	1650-1655	3.85	Dolomite Marlst.	1910-1915	3.58
Dolomite Marlst.	1655-1660	4.12	Dolomite Marlst.	1915-1920	3.68
Dolomite Marlst.	1660-1665	3.04	Dolomite Marlst.	1920-1925	5.14
Dolomite Marlst.	1665-1670	3.96	Dolomite Marlst.	1925-1930	3.89
Dolomite Marlst.	1670-1675	6.68	Dolomite Marlst.	1930-1935	4.33
Dolomite Marlst.	1675-1680	6.60	Dolomite Marlst.	1935-1940	3.96
Dolomite Marlst.	1680-1685	6.53	Dolomite Marlst.	1940-1945	4.40
Dolomite Marlst.	1685-1690	6.45	Dolomite Marlst.	1945-1950	4.74
Dolomite Marlst.	1690-1695	5.49	Dolomite Marlst.	1950-1955	3.05
Dolomite Marlst.	1695-1700	3.94	Dolomite Marlst.	1955-1960	4.98
Dolomite Marlst.	1700-1705	4.93	Dolomite Marlst.	1960-1965	5.54
Dolomite Marlst.	1705-1710	5.55	Dolomite Marlst.	1965-1970	5.08
Dolomite Marlst.	1710-1715	5.50	Dolomite Marlst.	1970-1975	6.10
Dolomite Marlst.	1715-1720	4.94	Dolomite Marlst.	1975-1980	6.24
Dolomite Marlst.	1720-1725	6.01	Dolomite Marlst.	1980-1985	5.69
Dolomite Marlst.	1725-1730	4.61			
Dolomite Marlst.	1730-1735	5.08	Dolomite Marlst.	1990-1995	6.25
Dolomite Marlst.	1735-1740	4.28	Dolomite Marlst.	1995-2000	6.57
Dolomite Marlst.	1740-1745	5.12	Dolomite Marlst.	2000-2005	5.60
Dolomite Marlst.	1745-1750	4.13	Dolomite Marlst.	2005-2010	5.61
Dolomite Marlst.	1750-1755	4.93	Dolomite Marlst.	2010-2015	4.05
Dolomite Marlst.	1755-1760	4.72	Dolomite Marlst.	2015-2020	5.24
Dolomite Marlst.	1760-1765	3.38	Dolomite Marlst.	2020-2025	6.27
Dolomite Marlst.	1765-1770	3.15	Dolomite Marlst.	2025-2030	6.26
Dolomite Marlst.	1770-1775	4.06	Dolomite Marlst.	2030-2035	5.50
Dolomite Marlst.	1775-1780	4.00	Dolomite Marlst.	2035-2040	4.52
Dolomite Marlst.	1780-1785	3.38	Dolomite Marlst.	2040-2045	2.26
Dolomite Marlst.	1785-1790	4.04	Dolomite Marlst.	2045-2050	4.19
Dolomite Marlst.	1790-1795	3.37	Dolomite Marlst.	2050-2055	2.72
Dolomite Marlst.	1795-1800	5.86	Dolomite Marlst.	2055-2060	2.58
Dolomite Marlst.	1800-1805	5.56	Dolomite Marlst.	2060-2065	6.09
Dolomite Marlst.	1805-1810	4.37	Dolomite Marlst.	2065-2070	3.52
Dolomite Marlst.	1810-1815	6.56	Dolomite Marlst.	2070-2075	5.93
Dolomite Marlst.	1815-1820	6.27	Dolomite Marlst.	2075-2080	5.14
Dolomite Marlst.	1820-1825	6.62	Dolomite Marlst.	2080-2085	2.71
Dolomite Marlst.	1825-1830	5.33	Dolomite Marlst.	2085-2090	5.38
Dolomite Marlst.	1830-1835	6.82	Dolomite Marlst.	2090-2095	5.96
Dolomite Marlst.	1835-1840	6.17	Dolomite Marlst.	2095-2100	5.11
Dolomite Marlst.	1840-1845	5.86	Dolomite Marlst.	2100-2105	5.05
Dolomite Marlst.	1845-1850	5.67	Dolomite Marlst.	2105-2110	3.09
Dolomite Marlst.	1850-1855	5.79	Dolomite Marlst.	2110-2115	4.31
Dolomite Marlst.	1855-1860	5.88	Dolomite Marlst.	2115-2120	4.03
Dolomite Marlst.	1860-1865	4.97	Dolomite Marlst.	2120-2125	3.82
Dolomite Marlst.	1865-1870	5.53	Dolomite Marlst.	2125-2130	3.80
Dolomite Marlst.	1870-1875	5.04	Dolomite Marlst.	2130-2135	3.23
Dolomite Marlst.	1875-1880	5.80	Dolomite Marlst.	2135-2140	3.24
Dolomite Marlst.	1880-1885	5.34			

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Dolomite Marlst.	2140-2145	2.74	Dolomite Marlst.	2390-2395	2.96
Dolomite Marlst.	2145-2150	2.91	Dolomite Marlst.	2395-2400	2.88
Dolomite Marlst.	2150-2155	4.12	Dolomite Marlst.	2400-2405	2.36
Dolomite Marlst.	2155-2160	3.19	Dolomite Marlst.	2405-2410	2.69
Dolomite Marlst.	2160-2165	2.72	Dolomite Marlst.	2410-2415	2.99
Dolomite Marlst.	2165-2170	2.64	Dolomite Marlst.	2415-2420	4.39
Dolomite Marlst.	2170-2175	3.02	Dolomite Marlst.	2420-2425	4.90
Dolomite Marlst.	2175-2180	2.59	Dolomite Marlst.	2425-2430	6.65
Dolomite Marlst.	2180-2185	2.03	Dolomite Marlst.	2430-2435	6.24
Dolomite Marlst.	2185-2190	2.12	Dolomite Marlst.	2435-2440	5.28
Dolomite Marlst.	2190-2195	2.92	Dolomite Marlst.	2440-2445	5.24
Dolomite Marlst.	2195-2200	2.94	Dolomite Marlst.	2445-2450	4.06
Dolomite Marlst.	2200-2205	3.16	Dolomite Marlst.	2450-2455	4.89
Dolomite Marlst.	2205-2210	3.77	Dolomite Marlst.	2455-2460	3.97
Dolomite Marlst.	2210-2215	4.44	Dolomite Marlst.	2460-2465	5.53
Dolomite Marlst.	2215-2220	3.95	Dolomite Marlst.	2465-2470	5.93
Dolomite Marlst.	2220-2225	5.84	Dolomite Marlst.	2470-2475	4.67
Dolomite Marlst.	2225-2230	4.85	Dolomite Marlst.	2475-2480	4.17
Dolomite Marlst.	2230-2235	4.80	Dolomite Marlst.	2480-2485	4.25
Dolomite Marlst.	2235-2240	4.56	Dolomite Marlst.	2485-2490	5.15
Dolomite Marlst.	2240-2245	5.86	Dolomite Marlst.	2490-2495	3.27
Dolomite Marlst.	2245-2250	4.00	Dolomite Marlst.	2495-2500	3.89
Dolomite Marlst.	2250-2255	4.05			
Dolomite Marlst.	2255-2260	4.96			
Dolomite Marlst.	2260-2265	4.99			
Dolomite Marlst.	2265-2270	4.56			
Dolomite Marlst.	2270-2275	3.58			
Dolomite Marlst.	2275-2280	4.90			
Dolomite Marlst.	2280-2285	3.97			
Dolomite Marlst.	2285-2290	3.53			
Dolomite Marlst.	2290-2295	3.92			
Dolomite Marlst.	2295-2300	3.59			
Dolomite Marlst.	2300-2305	3.47			
Dolomite Marlst.	2305-2310	2.28			
Dolomite Marlst.	2310-2315	2.62			
Dolomite Marlst.	2315-2320	2.75			
Dolomite Marlst.	2320-2325	2.15			
Dolomite Marlst.	2325-2330	2.78			
Dolomite Marlst.	2330-2335	2.11			
Dolomite Marlst.	2335-2340	2.97			
Dolomite Marlst.	2340-2345	1.78			
Dolomite Marlst.	2345-2350	2.45			
Dolomite Marlst.	2350-2355	2.14			
Dolomite Marlst.	2355-2360	2.92			
Dolomite Marlst.	2360-2365	3.93			
Dolomite Marlst.	2365-2370	4.58			
Dolomite Marlst.	2370-2375	3.93			
Dolomite Marlst.	2375-2380	3.41			
Dolomite Marlst.	2380-2385	4.12			
Dolomite Marlst.	2385-2390	3.66			

A P P E N D I X 4

Calcium Analysis:

Albert Mines Diamond Drill Hole #76-6



Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Clay Marlst.	225-230	4.08	Dolomite Marlst.	530-535	5.95
Clay Marlst.	230-235	2.41	Dolomite Marlst.	535-540	7.00
Clay Marlst.	235-240	1.67	Dolomite Marlst.	540-545	5.60
Clay Marlst.	243-245	3.84	Dolomite Marlst.	545-550	4.87
Clay Marlst.	245-250	3.95	Dolomite Marlst.	550-555	4.86
Clay Marlst.	250-253	2.47	Dolomite Marlst.	555-560	5.39
Clay Marlst.	255-260	2.82	Dolomite Marlst.	560-565	5.53
Clay Marlst.	260-265	1.54	Dolomite Marlst.	565-570	5.12
Clay Marlst.	265-270	1.36	Dolomite Marlst.	570-575	5.27
Clay Marlst.	270-275	1.59	Dolomite Marlst.	575-580	4.59
Clay Marlst.	275-280	1.75	Dolomite Marlst.	580-585	4.51
Clay Marlst.	280-285	1.63	Dolomite Marlst.	585-590	4.71
Clay Marlst.	285-290	4.91	Dolomite Marlst.	590-595	3.88
Clay Marlst.	290-295	8.24	Dolomite Marlst.	595-600	4.11
Clay Marlst.	295-300	3.19	Dolomite Marlst.	600-605	4.15
Clay Marlst.	300-305	2.19	Dolomite Marlst.	605-610	4.56
Clay Marlst.	305-310	3.75	Dolomite Marlst.	610-615	3.81
Clay Marlst.	310-315	8.31	Dolomite Marlst.	615-620	5.83
Clay Marlst.	315-320	6.20	Dolomite Marlst.	620-625	6.36
Clay Marlst.	320-325	6.94	Dolomite Marlst.	625-630	5.65
Clay Marlst.	325-330	7.74	Dolomite Marlst.	630-635	4.10
Clay Marlst.	330-335	4.83	Dolomite Marlst.	635-640	4.77
Clay Marlst.	335-340	2.35	Dolomite Marlst.	640-645	5.80
Clay Marlst.	350-355	1.62	Dolomite Marlst.	645-650	5.15
Clay Marlst.	355-360	5.80	Dolomite Marlst.	650-655	4.11
Clay Marlst.	360-365	6.20	Dolomite Marlst.	655-660	3.73
Clay Marlst.	365-370	4.16	Dolomite Marlst.	660-665	3.80
Clay Marlst.	370-375	2.60	Dolomite Marlst.	665-670	4.17
Clay Marlst.	375-380	4.80	Dolomite Marlst.	670-675	2.91
Clay Marlst.	380-385	4.22	Dolomite Marlst.	675-680	3.27
Dolomite Marlst.	415-420	7.35	Dolomite Marlst.	680-685	3.40
Dolomite Marlst.	420-425	5.03	Dolomite Marlst.	685-690	3.06
Dolomite Marlst.	425-430	4.21	Dolomite Marlst.	690-695	2.60
Dolomite Marlst.	430-435	3.55	Dolomite Marlst.	695-700	6.82
Dolomite Marlst.	435-440	4.42	Dolomite Marlst.	700-705	4.95
Dolomite Marlst.	440-445	4.81	Dolomite Marlst.	705-710	6.08
Dolomite Marlst.	445-450	4.31	Dolomite Marlst.	710-715	6.28
Dolomite Marlst.	450-455	4.76	Dolomite Marlst.	715-720	5.41
Dolomite Marlst.	455-460	7.69	Dolomite Marlst.	720-725	4.82
Dolomite Marlst.	460-465	4.10	Dolomite Marlst.	725-730	5.73
Dolomite Marlst.	465-470	4.32	Dolomite Marlst.	730-735	5.67
Dolomite Marlst.	470-475	7.25	Dolomite Marlst.	735-740	5.40
Dolomite Marlst.	475-480	5.23	Dolomite Marlst.	740-745	4.70
Dolomite Marlst.	480-485	7.56	Dolomite Marlst.	745-750	6.18
Dolomite Marlst.	485-490	7.41	Dolomite Marlst.	750-755	4.09
Dolomite Marlst.	490-500	5.37	Dolomite Marlst.	755-760	3.27
Dolomite Marlst.	500-505	7.92	Dolomite Marlst.	760-765	3.90
Dolomite Marlst.	505-510	2.77	Dolomite Marlst.	765-770	3.74
Dolomite Marlst.	510-515	2.59	Dolomite Marlst.	770-775	4.02
Dolomite Marlst.	515-520	2.80	Dolomite Marlst.	775-780	4.20
Dolomite Marlst.	520-525	3.86	Dolomite Marlst.	780-785	4.29
Dolomite Marlst.	525-530	5.29	Dolomite Marlst.	805-810	4.35

Lithologic Zone	Sampled Interval (Feet)	Ca (%)	Lithologic Zone	Sampled Interval (Feet)	Ca (%)
Dolomite Marlst.	805-810	5.06	Dolomite Marlst.	1070-1075	5.89
Dolomite Marlst.	810-815	5.52	Dolomite Marlst.	1075-1080	7.40
Dolomite Marlst.	815-820	5.70	Dolomite Marlst.	1080-1085	5.36
Dolomite Marlst.	820-825	5.66	Dolomite Marlst.	1085-1090	6.08
Dolomite Marlst.	825-830	3.78	Dolomite Marlst.	1090-1095	5.58
Dolomite Marlst.	830-835	5.67	Dolomite Marlst.	1095-1100	6.88
Dolomite Marlst.	835-840	5.46	Dolomite Marlst.	1100-1105	5.12
Dolomite Marlst.	840-845	4.63	Dolomite Marlst.	1105-1110	4.51
Dolomite Marlst.	845-850	4.45	Dolomite Marlst.	1110-1115	5.55
Dolomite Marlst.	850-855	3.63	Dolomite Marlst.	1115-1120	4.04
Dolomite Marlst.	855-860	6.02	Dolomite Marlst.	1120-1125	4.49
Dolomite Marlst.	860-865	5.04	Dolomite Marlst.	1125-1130	3.73
Dolomite Marlst.	865-870	6.14	Dolomite Marlst.	1130-1135	3.67
Dolomite Marlst.	870-875	6.74	Dolomite Marlst.	1135-1140	3.35
Dolomite Marlst.	875-880	5.59	Dolomite Marlst.	1140-1145	3.80
Dolomite Marlst.	880-885	4.48	Dolomite Marlst.	1145-1150	4.11
Dolomite Marlst.	885-890	5.26			
Dolomite Marlst.	890-895	4.64			
Dolomite Marlst.	895-900	4.03			
Dolomite Marlst.	900-905	3.99			
Dolomite Marlst.	905-910	3.77			
Dolomite Marlst.	910-915	3.37			
Dolomite Marlst.	915-920	4.95			
Dolomite Marlst.	920-925	5.02			
Dolomite Marlst.	925-930	4.04			
Dolomite Marlst.	930-935	3.84			
Dolomite Marlst.	935-940	4.36			
Dolomite Marlst.	940-945	5.36			
Dolomite Marlst.	945-950	5.53			
Dolomite Marlst.	950-955	4.66			
Dolomite Marlst.	955-960	4.58			
Dolomite Marlst.	960-965	4.79			
Dolomite Marlst.	965-970	5.58			
Dolomite Marlst.	970-975	4.38			
Dolomite Marlst.	975-980	3.26			
Dolomite Marlst.	980-985	3.48			
Dolomite Marlst.	985-990	2.56			
Dolomite Marlst.	990-995	2.63			
Dolomite Marlst.	995-1000	2.85			
Dolomite Marlst.	1000-1005	2.96			
Dolomite Marlst.	1005-1010	2.72			
Dolomite Marlst.	1015-1020	2.71			
Dolomite Marlst.	1020-1025	2.99			
Dolomite Marlst.	1025-1030	5.14			
Dolomite Marlst.	1030-1035	5.55			
Dolomite Marlst.	1035-1040	4.50			
Dolomite Marlst.	1040-1045	2.92			
Dolomite Marlst.	1045-1050	3.15			
Dolomite Marlst.	1050-1055	2.60			
Dolomite Marlst.	1055-1060	2.84			
Dolomite Marlst.	1060-1065	3.51			
Dolomite Marlst.	1065-1070	4.98			

**MAPS
NOT
FILMED**

**CARTES
OMISES**